





FIG. 1B

FIG.  
2A

FIG.  
2B

FIG. 2

## PV. LIMITS BASED ON INCREASING SPEED AND INCREASING PRESSURE

TEST #	POLYMERIC MATRIX	COMMERCIALY AVAILABLE COMPETITIVE MATERIALS (PREBLENDED)	COMPOSITIONS		
			POLYMERIC MATRIX MATERIALS USED FOR EXEMPLARY COMPOSITIONS	%	FIRST ADDITIVE
1	PEI		ULTEM 1010	55	DKD FIBER
2	PEI		ULTEM 1010	55	DKD FIBER
3	PEI		ULTEM 1010	55	DKD FIBER
4	PEI		ULTEM 1010	55	DKD FIBER
5	PEI		ULTEM 1010	55	DKD FIBER
6	PEI		ULTEM 1010	50	DKD FIBER
7	PEI		ULTEM 1010	70	TFE FIBER
8	PEI		ULTEM 1010	70	DKA FIBER
9	PEI		ULTEM 1010	60	DKA FIBER
10	PEI		ULTEM 1010	50	DKA FIBER
11	PEI		ULTEM 1010	40	DKAFIBER
12	PEI		ULTEM 1010	30	DKD FIBER
13	PEI		ULTEM 1010	100	
14	PEI	ULTEM 7201		80	CARBON FIBER
15	PEI	ULTEM 7301		75	CARBON FIBER
16	PEI	EL 4040		80	
17	PEEK		VICTREX 150	55	DKD FIBER
18	PEEK		VICTREX 150	55	DKD FIBER
19	PEEK		VICTREX 150	55	DKD FIBER
20	PEEK	VICTREX FC 30		70	CARBON FIBER
21	PEEK	VICTREX FC 30		70	CARBON FIBER
22	PEEK	VICTREX CA 30		70	CARBON FIBER
23	PEEK	VICTREX CA 30		70	CARBON FIBER
24	PI		AUREM	55	DKD FIBER
25	PI/PEI		AUREM/ULTEM 1010	44/11	DKD FIBER
26	PI/PEI		AUREM/ULTEM 1010	37.5/12.5	DKD FIBER
27	PI	AUREM JNF 3020		80	
28	PI	AUREM JNF 3025			
29	PI	AUREM JCN 6530		70	CARBON FIBER
30	PI	AUREM JCF 6525			CARBON FIBER
31	LCP/PEI		LCP/ULTEM 1010	37.5/12.5	DKD FIBER
32	LCP	VECTRA B230		70	CARBON FIBER
33	PPS		TICONA 020584	55	DKD FIBER
34	PPS		TICONA 020584	50	DKD FIBER
35	PPS	OL 4060		70	
36	PAI	TORION 7130		70	CARBON FIBER
37	PAI	TORION 4301		85	

FIG. 2A

## PV. LIMITS BASED ON INCREASING SPEED AND INCREASING PRESSURE

COMPOSTIONS					PV LIMIT	PV LIMIT
	%	SECOND ADDITIVE(S)	%	METHOD OF BLENDING	BASED ON INCREASING VELOCITY @100 PSI	BASED ON INCREASING PRESSURE @25 FPM
30		TFE FIBER	15	SOLVENT	90,000	50000+
30		TFE FIBER	15	SOLVENT	97,000+	65000+
30		TFE FIBER	15	SOLVENT	90,000+	
30		TFE FIBER	15	DRY	60,000	
30		TFE POWDER	15	SOLVENT	60,000	
25		BN PLATELETS	25	SOLVENT	90,000+	
30				SOLVENT	40,000	
30				SOLVENT	30,000	
40				SOLVENT	50,000	
50				SOLVENT	60,000	
60				SOLVENT	70,000	
60		BN PLATELETS	10	SOLVENT	90,000+	
				PREBLEND	<10,000	
20				PREBLEND	40,000	
25				PREBLEND	20,000	
		TFE POWDER	20	PREBLEND	20,000	
30		BN PLATELETS	15	DRY	60,000	
30		BN PLATELETS	15	DRY	50,000	
25		BN PLATELETS	25	DRY	80,000	
10		GRAPHITE POWDER/TFE POWER	10/10	PREBLEND	30,000	30,000
10		GRAPHITE POWDER/TFE POWER	10/10	PREBLEND	40,000	30,000
30				PREBLEND	30,000	30,000
30				PREBLEND	50,000	40,000
30		TFE FIBER	15	DRY	70,000	
30		TFE FIBER	15	CONCENTRATE	90,000	
25		BN PLATELETS	25	CONCENTRATE	90,000	
		TFE POWDER	20	PREBLEND	50,000	50,000
		TFE POWDER		PREBLEND	40,000	30,000
30				PREBLEND	40,000	45,000
				PREBLEND	40,000	30,000
25		BN PLATELETS	25	CONCENTRATE	90,000	
30				PREBLEND	10,000	15,000
30		TFE FIBER	15	DRY	50,000	56,000
25		BN PLATELETS	25	DRY	50,000	
		TFE POWDER	30	PREBLEND	30,000	30,000
30				PREBLEND	30,000	35,000
		GRAPHITE POWDER/TFE POWER	12/3	PREBLEND	30,000	20,000

FIG. 2B

**BEARING WEAR PROPERTIES OF THE PRESENT COMPOSITIONS  
IN COMPARISON TO COMMERCIALY AVAILABLE COMPOSITIONS**

TEST #	POLYMERIC MATRIX	COMMERCIALY AVAILABLE COMPETITIVE MATERIALS (PREBLENDED)	COMPOSITIONS		
			POLYMERIC MATRIX MATERIALS USED FOR EXEMPLARY COMPOSITIONS	%	FIRST ADDITIVE
38	PEI		ULTEM 1010	55	DKD FIBER
39	PEI		ULTEM 1010	55	DKD FIBER
40	PEI		ULTEM 1010	55	DKD FIBER
41	PEI		ULTEM 1010	50	DKD FIBER
42	PEI		ULTEM 1040	30	DKD FIBER
43	PEI	ULTEM 7201		80	CARBON FIBER
44		EL4040		80	
45	PEEK		VICTREX 150	55	DKD FIBER
46	PEEK		VICTREX 150	55	DKD FIBER
47	PEEK		VICTREX 150	50	DKD FIBER
48	PEEK		VICTREX 150	50	DKD FIBER
49	PEEK		VICTREX 150	30	DKD FIBER
50	PEEK		VICTREX 150/ULTEM 1010	41/9	DKD FIBER
51	PEEK	VICTREX FC30		70	CARBON FIBER
52	PEEK	VICTREX CA30		70	CARBON FIBER
53	PEEK	EL 4030		85	
54	PI/PEI		AUREM/ULTEM 1010	44/11	DKD FIBER
55	PI/PEI		AUREM/ULTEM 1010	37.5/12.5	DKD FIBER
56		AUREM JCF 6525			
57	PI	AUREM JCN 6530		70	CARBON FIBER
58	PI	AUREM JCF 3020		80	
59	LCP/PEI		LCP/ULTEM 1010	37.5/12.5	DKD FIBER
60	LCP	XYDAR 96043		40	CARBON FIBER
61	LCP	VICTRA E230		70	CARBON FIBER
62	PPS		TICONA 020584	55	DKD FIBER
63	PPS		TICONA 020584	50	DKD FIBER
64	PPS	DL 4040		80	
65	PPS	1350AR15TFE15		70	ARAMID FIBER
FOOTNOTE 1: THE PV LIMIT BASED ON INCREASING SPEED AT 200 PSI IS:					
		PV LIMIT	SHAFT TEMPERATURE	COEFFICIENT OF FRICTION	
		180,000	315	0.02	
		180,000	310	0.03	

FIG. 3A	FIG. 3B	FIG. 3C
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FIG. 3A

FIG. 3

## BEARING WEAR PROPERTIES OF THE PRESENT COMPOSITIONS IN COMPARISON TO COMMERCIALY AVAILABLE COMPOSITIONS

COMPOSITIONS				
	%	SECOND ADDITIVE(S)	%	METHOD OF BLENDING
	30	TFE FIBER	15	SOLVENT
	30	TFE FIBER	15	EXTRUSION
	30	TFE POWDER	15	SOLVENT
	25	BN PLATELETS	25	SOLVENT
	60	BN PLATELETS	10	SOLVENT
	20			PREBLEND
		TFE POWDER	20	
	30	TFE FIBER	15	DRY
	30	BN PLATELETS	15	DRY
	25	BN PLATELETS	25	DRY
	25	BN PLATELETS	25	EXTRUSION
	70			DRY
	25	BN PLATELETS	25	CONCENTRATE
	10	GRAPHITE POWDER TFE POWDER	10/10	PREBLEND
	30			PREBLEND
		TFE POWDER	15	PREBLEND
	30	TFE FIBER	15	CONCENTRATE
	25	BN PLATELETS	25	CONCENTRATE
				PREBLEND
	30			PREBLEND
		TFE FIBER	20	PREBLEND
	25	BN PLATELETS	25	CONCENTRATE
	60			PREBLEND
	30			PREBLEND
	30	TFE FIBER	15	DRY
	25	BN PLATELETS	25	DRY
		TFE POWDER	20	PREBLEND
	15	TFE POWDER	15	PREBLEND

FIG. 3B

[illegible]

FIG. 3C

**FOOTNOTES:**

1. AFTER 1 HOUR
2. AFTER 3 HOURS
3. AFTER 5 MINUTES
4. AFTER 15 MINUTES
5. AFTER 1 MINUTE

FIG. 4A

FIG. 4

WEAR PROPERTIES AT HIGH VALUES OF PRESSURE X VELOCITY

WEAR (K)										SHAFT TEMPERATURE (F)					COEFFICIENT OF FRICTION				
PRESSURE X VELOCITY										PRESSURE X VELOCITY					PRESSURE X VELOCITY				
10,000	20,000	40,000	80,000	100,000	10,000	20,000	40,000	80,000	100,000	10,000	20,000	40,000	80,000	100,000					
200x50	200x100	200x200	200x400	200x500	200x50	200x100	200x200	200x400	200x500	200x50	200x100	200x200	200x400	200x500					
16	61	70	MELTED(1)		180	210	330	MELTED(1)		0.21	0.24	0.12	MELTED(1)						
23		72	MELTED(5)		220		340	MELTED(5)		0.28		0.14	MELTED(5)						
12		55	35	MELTED(2)	160		241	220	MELTED(2)	0.19		0.1	0.04	MELTED(2)					
12	18	50	23	79	174		229	260	205	0.24	0.17	0.12	0.1	0.05					
39	40	30	84	43	160	155	165	260	200	0.24	0.2	0.2	0.08	0.08					
79																			
19	63	63	229	MELTED(6)	250	250	290	460	MELTED(6)	0.3	0.2	0.1	0.08	MELTED(6)					
10		22	91	MELTED	240		259	270	MELTED	0.2		0.08	0.06	MELTED					
2	36			33	160	193			230	0.2	0.2			0.06					
22	31	16	25	19	140	170	193	175	175	0.2		0.08	0.06	0.04					
12	25	22	20	15	167	200	222	225	200	0.2	0.16	0.08	0.1	0.04					
251	MELTED				260	MELTED				0.2	MELTED								
120	MELTED				375	MELTED				0.7	MELTED								
16	46	32	74	MELTED	200	250	245	250	MELTED(4)	0.28	0.3	0.12	0.1	MELTED(4)					
50	46	51	MELTED	390	180	295	360	MELTED	475	0.34	0.32	0.26	MELTED	MELTED(4)					
110	165	MELTED(3)																	
20		80	MELTED(5)		220		315	MELTED(5)		0.32		0.14	MELTED(5)						
4	20	46	32	MELTED(5)	190		235	217	MELTED(5)	0.18		0.12	0.04	MELTED(5)					
201	MELTED(1)	MELTED(3)			340	MELTED(1)	MELTED(3)			0.48	MELTED(1)	MELTED(3)							
143	287				150	270				0.19	0.2								

FIG. 4B

FIG. 5A  
FIG. 5B

FIG. 5

## BEARING WEAR PROPERTIES AT HIGH LOADS AND LOW SPEEDS

TEST #	POLYMERIC MATRIX	COMMERCIALLY AVAILABLE COMPETITIVE MATERIALS (PREBLENDED)	COMPOSITIONS				
			POLYMERIC MATRIX MATERIALS USED FOR EXEMPLARY COMPOSITIONS	%	FIRST ADDITIVE	%	SECOND ADDITIVE(S)
86	PEI		ULTEM 1010	55	DKD FIBER	30	TFE FIBER
87	PEI		ULTEM 1010	50	DKD FIBER	25	BN PLATELETS
88	PEI		ULTEM 1010	30	DKD FIBER	60	BN PLATELETS
89	PEI		ULTEM 1040	28	DKD FIBER	70	DC4-7105
90	PEI	ULTEM 7201		80	CARBON FIBER	20	
91	PEEK		VICTREX 150	55	DKD FIBER	30	TFE FIBER
92	PEEK		VICTREX 150	50	DKD FIBER	25	BN PLATELETS
93	PEEK		VICTREX 150	29	DKD FIBER	70	CAPOW L38/H
94	PEEK		VICTREX 150	48	DKD FIBER	25	BN PLATELETS/DC4-7105
95	PEEK		VICTREX 150	48	DKD FIBER	25	BN PLATELETS/DC4-7105
96	PEEK	VICTREX FC30		70	CARBON FIBER	10	GRAPHITE POWDER/TFE POWDER
97	PEEK	VICTREX CA30		70	CARBON FIBER	30	
98	PPS		TICONA 020584	28	DKD FIBER	70	DC4-7105
99	PPS		TICONA 020584	30	DKD FIBER	10	GRAPHITE POWDER
100	PPS	OL 4040		80			TFE POWDER

FIG. 5A

# BEARING WEAR PROPERTIES AT HIGH LOADS AND LOW SPEEDS

%	METHOD OF BLENDING	WEAR (K)	SHAFT TEMPERATURE (F)	COEFFICIENT OF FRICTION
15	SOLVENT	15	280	0.2
25	SOLVENT	38	160	0.32
10	SOLVENT	28	170	0.3
2	SOLVENT	9	143	0.13
	PREBLEND	MELTED	MELTED	MELTED
15	DRY	33	230	0.06
25	DRY	20	180	0.09
1	DRY	19	210	0.1
25/2	DRY	20	250	0.1
25/2	DRY	11	180	0.16
10/10	PREBLEND	MELTED	MELTED	MELTED
	PREBLEND	MELTED	MELTED	MELTED
2	CONCENTRATE	33	250	0.17
60	CONCENTRATE	124	250	0.36
20	PREBLEND	MELTED	MELTED	MELTED

FIG. 5B

ADDITIVE	THERMAL CONDUCTIVITY (W/m°C)
ALUMINUM FLAKE	204
BORON NITRIDE POWDER	33-200
BRONZE POWDER	26
GRAPHITE POWDER	
STEEL FIBER	52
STAINLESS STEEL FIBER	12-22

FIG. 6

POLYMERIC MATRIX MATERIAL	COMPOSITION						WEAR (K)	SHAFT TEMP (°F)	CO- EFFIC- IENT OF FRIC- TION	TEST DURATION (HRS.)
	FIRST ADDITIVE	SECOND ADDITIVE	% BY VOLUME	% BY WEIGHT	TYPE OF CARBON FIBER	METHOD OF BLENDING				
PEI ULTEM 1040	DKD		70/30	57.5/42.5	PITCH	SOLVENT	26	175	0.34	24
PEI ULTEM 1040	DKD		60/40	46/54	PITCH	SOLVENT	37	163	0.22	24
PEI ULTEM 1040	AGM 94		70/30	62/38	PAN	SOLVENT	206	360	0.44	24
PEI ULTEM 1010	AGM 94		60/40	51/49	PAN	SOLVENT	366	205	0.4	26
PEI ULTEM 1010	AGM 94		50/50	41/59	PAN	SOLVENT	210	280	0.4	24
PEI ULTEM 1040	AGM 95		50/50	40/60	PITCH	SOLVENT	180	290	0.34	24
PEI ULTEM 1040	AGM 94		43/57	35/65	PAN	SOLVENT	530	200	0.44	24
PEI ULTEM 1010	AGM 94	BN PLATELETS	60/20/20	49/23/28	PAN	SOLVENT	10,000+	260	0.46	0.16
PEI ULTEM 1040	VMX-24	BN PLATELETS	60/20/20	48/24/28	PITCH	SOLVENT	10,000+	229	0.5	1
PEI ULTEM 1040	VMX-24		60/40	50/50	PITCH	SOLVENT	112	370+	0.7	21
PEEK	DIALEAD K223 HG	BN PLATELETS	60/40	48/52	PITCH	DRY	12	140	0.14	24
PPS	DKD		60/40	48/52	PITCH	DRY	24	225	0.3	24

FIG. 7A  
FIG. 7B

FIG. 7

FIG. 7A

PPS	DIALEAD K223 HG	BN PLATELETS	64/18/18	50/25/25	PITCH	DRY	6	125	0.22	24
PPS	FORTAFIL				PAN	DRY	599	253	0.36	24
PPS	DIALEAD K223 HG LF	BN PLATELETS			PITCH	DRY	6	180	0.36	24
PC	DKD	BN PLATELETS	60/20/20	47/27/27	PITCH	SOLVENT	70	141	0.16	24
PC	GM 130	BN PLATELETS	60/20/20	48/23/29	PAN	SOLVENT	9875	300	0.36	2
PEI ULTEM 1040	DKD		87.5/12.5	80/20	PITCH	SOLVENT	57	195	0.24	24
PEI ULTEM 1010	DKD		64/36	50/50	PITCH	SOLVENT	24	190	0.26	100
PEI ULTEM 1010	DKD		54/46	40/60	PITCH	SOLVENT	38	176	0.34	24
PEI ULTEM 1010	DKD		43/57	30/70	PITCH	SOLVENT	29	158	0.24	100
PEI ULTEM 1010	DKD	BN PLATELETS	43/49/8	30/60/10	PITCH	SOLVENT	12	174	0.24	100
PEI ULTEM 1010	DKD	BN PLATELETS	64/18/18	50/25/25	PITCH	SOLVENT	12	160	0.18	100

FIG. 7B

PRODUCT NAME	SUPPLIER	TYPE OF FIBER	T <sub>c</sub> (W/mC)		DENSITY (gm/cc)	AVERAGE DIAMETER (MICRONS)	AVERAGE LENGTH (MICRONS)	ASPECT RATIO
DKA	BPAMOCO CORPORATION	PITCH	900		2.2	10	200	
DKD	BPAMOCO CORPORATION	PITCH	600		2.2	10	200	
VMX-24	BPAMOCO CORPORATION	PITCH	22		1.9	11	200	
AGM 94	ASBURY GRAPHITE MILLS	PAN			1.81	7	150	
AGM 95	ASBURY GRAPHITE MILLS	PITCH			1.91	11	200	
FORTAFIL 382	FORTAFIL FIBERS INC.	PAN			1.8	7	175	
FORTAFIL 482	FORTAFIL FIBERS INC.	PAN			1.8	7	175	
GRAFIL GM130E	GRAPHIL INC.	PAN	7		1.8	7	130	
PYROFIL TR50S	GRAPHIL INC.	PAN	7		1.82	7	8000	
DIALEAD K 6371M	MITSHUBISHI CHEMICAL AMERICA	PITCH	140		2.1	7	50	
DIALEAD K 223HG LG	MITSHUBISHI CHEMICAL AMERICA	PITCH	540		2.2	7	6000	
DIALEAD K 223HG	MITSHUBISHI CHEMICAL AMERICA	PITCH	540		2.2	7	300	

FIG. 8

FIG. 9A  
9B

FIG. 9

TEST #	POLYMERIC MATRIX	COMPARATIVE COMPOSITIONS				
		POLYMERIC MATRIX MATERIALS USED FOR COMPARATIVE COMPOSITIONS	%	FIRST ADDITIVE	%	SECOND ADDITIVE(S)
101	PEI	ULTEM 1010		ALUMINUM FLAKE		
102	PPS		65	ALUMINUM FLAKE	16	BN PLATELETS
103	PEI	ULTEM 1010	60	BRONZE POWDER	40	
104	PEI	ULTEM 1040	60	BRONZE POWDER	20	GRAPHITE FLAKE
105	PEI	ULTEM 1040	60	STEEL FIBER	20	BN PLATELETS
106	PC		81	STAINLESS STEEL FIBER	19	
107	PEI	ULTEM 1010	60			BN PLATELETS
108	PEI	ULTEM 1010	64	AGM 3243 GRAPHITE	36	

FIG. 9A

WEAR PROPERTIES			
WEAR (K)	SHAFT TEMPERATURE (F)	COEFFICIENT OF FRICTION	TEST DURATION (HRS)
4400	150	<0.7	0.03
<10000	170	0.48	1
935	240	0.45	24
225	215	0.42	24
969	245	0.5	18
657	241	0.54	10.5
10,324	240	0.46	0.31
167	190	0.34	40

FIG. 9B

FIG. 10A
FIG. 10B

FIG. 10

MATRIX	% WGT.	FIBER	% WGT.	FILLER	% WGT.	IN- PLANE	THRU- PLANE	IN- PLANE
XYDAR 96403 LCP	40	DKD	60			2.85	5.13	
XYDAR 96403 LCP (REPROCESSED)	40	DKD	60			2.94	6.83	
PPS	40			ALUMINUM FLAKE	60	8.58	8.13	
PPS	30			ALUMINUM FLAKE	70	14.98	15.12	
PPS	20			ALUMINUM FLAKE	80	20	21.7	
PPS	40	DKD	30	ALUMINUM FLAKE	30	4.5	5.36	
PPS	50	DKD	50			2.52	4.65	
PPS	40	DKD	60			2.92	7.36	
PPS	30	DKD	70			5.38	9.5	
PPS	50			BORON NITRATE	50	0.8	1.1	
PEI	55	DKD	25	TEFLON FLOCK	25	0.99	1.6	
PEEK	50	DKD	25	BORON NITRIDE	25	1.15	2.86	

FIG. 10A

PPS	50			ALUMINUM FLAKE	50	1.76	2	
PEEK	30	DKD	70			4.39	10.5	
PEEK	50			BORON NITRIDE	50	1.69	2.1	
PPS	50			ALUMINUM FLAKE BORON NITRIDE	25/25			4.79
XYDAR 96403 LCP	40	DKD	60					1.97
PEI	50	DKA	50					1.44
PEI	50	DKD	25	BORON NITRIDE	25			1.56
FERRO 511TG 72001 PEN	40	BN PWD	60					3.82
PEI	70	DKA	30					0.82
PEI	60	DKA	40					1.03
PEI	40	DKA	60					2.51

FIG. 10B